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Effects of Competitive Funding on University Efficiency

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Abstract

This paper uses a panel data set containing universities across eight European countries to model an output distance function and analyze the impact of three competitive funding types on the production frontier and the university efficiency. We find little evidence for an effect of the budget share financed by tuition fees or private funds on the production frontier, but a significantly negative impact of international public funds. Similarly, only international public funds have an effect on efficiency. These findings are consistent with the hypothesis, that competitive funding reduces the frontier due to monitoring costs, but increases competition and therefore decreases inefficiency. Our findings remain robust to the inclusion of country-specific dummies and time trends, the use of lagged values and country averages as instruments and the variation of the identification strategy for university efficiency.

Preliminary Version

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1 Introduction

Universities face substantial pressure to use their funding in an efficient manner as public and private agencies tend to provide financial resources based on competitive funding. Besides, universities have become increasingly important as part of the national innovation system. Consequently, the interest to measure and evaluate university productivity has increased substantially by both the university management and the politics. But there are few articles analyzing the impact of different funding resources on productivity of universities. However, both the theoretical and empirical findings are ambiguous, indicating that further research in this area is required to allow policymakers to make evidence-based decisions (see e.g. Van der Ploeg and Veugelers, 2008).

Public authorities and other third-party agencies that decide on the distribution of financial resources are reliant on information such as performance measures to secure effective and efficient employment of funds. This is due to the fact that the relationship between a donor of third-party funds (principal) and researcher (agent) is typically modeled in a principal-agent framework (see e.g. Kivistö, 2005). Hence, the significance of applying analysis based on benchmarks and efficiency measurements in the public non-profit sectors such as higher education, health care or the cultural sector has become more important in recent years. Those techniques provide management as well as policy makers valuable information on efficient production because they allow the performance comparison of several decision making units against a benchmark, the so called production frontier, shaped by the most productive units.

In particular, a strand of the literature analyzes the relevance of funding restrictions on the efficiency of universities, reporting mixed results (see e.g. **?**Kempkes and Pohl, 2008; Kuo and Ho, 2007; Mensah and Werner, 2003). Following **?**, Kempkes and Pohl (2008) and Duh and Kuo (2006) the assumption appears to be confirmed that restrictive regulations and productivity are negatively related; universities are more efficient, the more autonomy is guaranteed by authorities. These findings give evidence for a misallocation effect. Because of the difference in the utility functions, the principal has an interest to control the agent's behavior through restrictions. The problem is that these restrictions are set by the principal facing incomplete information (see e.g. Schiller and Liefner, 2006).

However, the principal-agent relationship might also be result in a positive impact of restricting external funds on productivity due to moral hazard, because the restrictions on the employment of provided resources might decrease the ability of the agent to pursue his own goals at the expense of the donor (see e.g. Niskanen, 1971, 1975). Such a disciplining effect is supported by the results of Mensah and Werner (2003) who find a positive correlation between funding restriction and efficiency. Kuo and Ho (2007) present similar evidence. Finally, the most apparent channel is the administrative effect due to the monitoring costs, i.e. the acquisition of external funds requires the investment of time and money by the researcher. Therefore, the time available for productive activities decreases. However, unlike the misallocation and discipline effect, the administrative effect impacts the production frontier itself, but not the university efficiency.

Evidence of the overall effect of external funding and university efficiency are presented by Cherchye and Abeele (2005), who find a positive correlation between the share of total third-party funding and research efficiency. Bonaccorsi et al. (2006) analyze the impact of private funds on efficiency and find a U-shaped correlation for Italian universities, for which private funding is of rather limited relevance though. Using data on individual researchers at the Louis Pasteur University, Carayol and Matt (2006) distinguish between public and private third-party funding and find a small effect of public funds on individual productivity. Most importantly, **?** analyze the relationship between productivity and public third-party funding and find a positive relationship. They tackle identification of the causal effect using an elaborate instrument based on US political institutions.

This paper complements the existing literature and **?** in particular in a number of ways. First, we separately model the influence of third-party funding on the production frontier and the efficiency of universities, allowing us to disentangle the administrative effect from the misallocation and discipline effect. Secondly, the paper analyzes the effect of tuition fees, public international funding and private funds separately. Thirdly, we explore the econometric challenges of identifying inefficiency and the influence of budget shares in the presence of endogeneity and compare a number of possibilities. More generally, the panel data structure enables us to tackle a broad range of econometric problems in respect to the identification of causal effects. Most notable are the country-specific intercepts and trends that capture unobserved heterogeneity across countries. Moreover, we use lagged values and averages across a country to instrument budget shares. We also conduct a system GMM estimation to account for autocorrelation in the data. Fourthly, the provided evidence spans eight European countries: Switzerland, United Kingdom, Netherlands, Finland, Norway, Spain, Portugal and Italy, thereby revealing relationships that are valid beyond a particular political system.

We find strong evidence for the administrative effect in respect to public international funds, as these correlate negatively with the production frontier. Furthermore, we show that the share of the budget financed by public international funds has a positive effect on efficiency, indicating that the discipline effect dominates the misallocation effect. Private funds and tuition fees on the other hand have no impact on either production frontier or efficiency.

The estimation approach along with the specifications of the applied models are introduced in Section 2. Section 3 provide information on the data used for the analysis. Estimation results of the empirical analysis are presented in Section 4 followed by conclusions in Section 5.

2 Estimation Approach

The employed technique, labeled stochastic frontier analysis (SFA), has the benefit that it accommodates to statistical noise. Furthermore it allows the integration of third-party factors in the production function. Most notably in the context of a panel data set is the possibility to account for time invariant cross unit heterogeneity by using the econometric methodologies described in Greene (2005*a*) and Greene (2005*b*). Due to its parametric nature, the methodology has the drawback that it requires assumptions concerning the distribution of inefficiency and the error term in addition to the assumed functional form. However, using a translog functional form reduces the latter problem substantially as it provides a second order approximation of the true function.

Following Abbott and Doucouliagos (2009), we utilize an output distance function. This has the advantage that universities are modeled as output maximizing institutions, an assumption that appears reasonable as inputs of public research institutions are often decided upon by politicians. Furthermore, the use of wages appears problematic, as these are subject to strong regulation. Therefore, the distance function has the following form:

$$
\begin{aligned}
lny_{1,i,j,t} = \alpha_{i,j} + \sum_{m=2}^{M} \beta_m lny^*_{m,i,j,t} + \frac{1}{2} \sum_{m=2}^{M} \sum_{n=2}^{M} \gamma_{m,n} lny^*_{m,i,j,t} * lny^*_{n,i,j,t} \\
+ \sum_{k=1}^{K} \delta_k lnx_{k,i,j,t} + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \eta_{k,l} lnx_{k,i,j,t} * lnx_{l,i,j,t} \qquad (1) \\
+ \frac{1}{2} \sum_{k=1}^{K} \sum_{m=2}^{M} \theta_{k,m} lny^*_{k,i,j,t} * lnx_{m,i,j,t} + \gamma * bsha + \upsilon_{i,j} + \varepsilon_{1,i,j,t}
\end{aligned}
$$

where $lny_{1,i,j,t}$ refers to the number of enrolled students of university i in country j at time t. It captures the amount of teaching and serves as the normalizing output. The remaining outputs appear as explanatory variables normalized by students, meaning that $y^*_m = y_m/y_1$. These consist of the number of PhD students, also approximating teaching output and scientific publications capturing basic research. The vector x contains the amount of labor input differentiated by "Professors", "Assistant Professors", "Researchers", "Other Administrative Staff" and finally "Technical and Administrative Staff". $\epsilon_{j,t}$ refers to a normally distributed error term with mean zero and variance σ^2_ϵ. υ_j refers to inefficiency, or slack of the university. The observation specific but time-invariant intercepts, $\alpha_{i,j}$, capture time-invariant heterogeneity. However, due to the structure of the data, we generally include country-specific but not individual-specific intercepts in the estimation. In addition, we use country-specific trends to account for heterogeneous developments in the analyzed countries.

bsha is a vector of budget shares financed by tuition, international public grants and private funds. Including these explanatory variables in the distance function directly suggests the interpretation that funding competition affects the production frontier itself. Arguably, university management controls the shares of third-party funding by introducing corresponding incentives, implying that the funding shares influence efficiency but not the production frontier. In this case the proper econometric strategy consists of modeling efficiency as a function of the funding shares, but refrain from including them in the output distance function directly (see e.g. Cherchye and Abeele, 2005). However, to the extent that competition pressures universities at the boundary to increase their effort, the estimated production frontier might shift as well. Examples for the treatment of the funding structure as exogenous are Bonaccorsi et al. (2006) and Carayol and Matt (2006). In the following, we assume that the funding shares influence both efficiency and the distance frontier. Therefore, we also model inefficiency υ_j in the following inefficiency equation:

$$\upsilon_{i,j} = \phi + \varphi * bsha + \varepsilon_{2,i,j,t} \tag{2}$$

In order to retain a functional distribution of the inefficiency terms, we restrict ϕ_0 to zero.

We start our analysis by assuming that no inefficiencies or unobserved heterogeneity exists, i.e. $\alpha_{i,j}$ is a constant and $\upsilon_{i,j}$ is zero. The corresponding estimation technique is OLS. Including the shares of third-party funding in the output distance function directly yields descriptive evidence of the relationship between funding sources and productivity. This model yields estimates of the relationship between budget shares and the average production function. Inefficiencies are neither modeled nor identified in this specification.

Setting aside the issue of unobserved heterogeneity for the moment, we estimate a model that includes a full set of fixed effects. Pitt and Lee (1981) and Schmidt and Sickles (1984) suggest to interpret the predicted individual intercepts as inefficiency. In a second step, it is possible to regress the predicted individual intercepts on budget shares. In econometric terms, this amounts to estimating two OLS estimations. The benefit of this estimator is the flexibility in respect to the modeling strategy in the inefficiency equation. Furthermore, it allows us to disentangle changes in the production frontier and the efficiency of universities. However, this approach suffers from a simultaneity bias as the two equations should be estimated simultaneously. Furthermore, depending on the number of observations over time, T, the estimated individual intercepts suffer from an incidental parameter problem (see e.g. Lancaster, 2000). Another drawback is that the estimated efficiencies are constant over time.

Before moving towards an alternative identification strategy for inefficiency, we explore the possibility to account for reverse causality by employing a system GMM estimator. The reasoning behind this approach lies in the relevance of time-persistence in university performance due to self-reinforcing processes, e.g. good staff choosing universities with high reputation. Accounting for autocorrelation appears a natural and effective approach to deal with this type of endogeneity.

Alternatively, Aigner et al. (1977) as well as Meeusen and van den Broeck

(1977) propose to identify inefficiency by the assumption that inefficiencies follow a truncated normal distribution. Building on this idea, the methodology proposed by Battese and Coelli (1995) allows to estimate the inefficiencies and their determinants, i.e. funding shares simultaneously. However, this technique does not account for the panel structure of the data, implying that the original assumption of a half-normal distribution of inefficiencies across a cross-section needs to hold in the pooled version as well. In order to account for this issue, we estimate the two panel data frontiers proposed in Battese and Coelli (1992). The first assumes time-invariant inefficiency, while the latter allows inefficiency to develop over time according to:

$$\upsilon_{i,j,t} = exp\{-\eta(t - T_i)\}u_i \tag{3}$$

For this estimator, $\upsilon \neq u_i$ and therefore we perform the second stage regressions with technical efficiency υ instead of technical inefficiency as the dependent variable. This approach has the benefit that the expected signs are the same as the estimation based on a fixed effects estimator.

Greene (2005*a*) and Greene (2005*b*) criticizes the fact that the above models do not account for time invariant cross unit heterogeneity. This criticism becomes particularly relevant if the research question concerns the determinants of inefficiency, as a correlation between the unobserved heterogeneity and the error term results in an omitted variable bias that renders the estimated coefficients inconsistent. We approach this problem by including country-specific intercepts and, where possible, trends in the above estimations. This should capture a large part of worrisome heterogeneity.

In order to account for reverse causality, we use average funding shares at the country level to instrument for university-specific funding shares. The idea of the approach is that the political regime in a country is exogenous, implying that the average funding share is independent of the current level of university efficiency. This approach uses a very specific part of the observed variation, namely the variation between countries to test the impact of third-party funding on the efficiency of universities.

The use of past values of funding shares as an instrument for the current funding shares represents an alternative to using country level funding share averages as instruments. The problem with this methodology is that the corresponding econometric strategy is a three stage estimator that includes a truncated normal distributed inefficiency term in the third stage and an estimation of unobserved heterogeneity using simulation techniques. To our knowledge, such an estimator is not implemented in the standard software. Therefore we estimate distance functions in the first step, calculate predicted inefficiencies and regress these on a set of country dummies, country-specific trends and budget shares, where the latter can be instrumented using 2SLS. We address the problem of simultaneity by bootstrapping the standard errors of the inefficiency equation.

3 Data

The data used in this study stems from the Aquameth database[1], a European project that has established a data set which contains comparable statistics with respect to universities across a large number of European countries; that is Finland, Italy, Netherlands, Norway, Portugal, Spain, Switzerland and United Kingdom. The data is unbalanced, spanning from 1994 to 2006.

We use information on the number of enrolled Bachelor and Master students as well as the number of PhD students to capture teaching output of the universities. The number of publications reflects the output of research. Five labor categories serve as inputs ("Professors", "Assistant Professors", "Researchers", "Other Administrative Staff" and finally "Technical and Administrative Staff"). Note that despite all efforts, the definition of input variables varies across countries. Most notably, not all countries report full-time equivalent employment contracts. Furthermore, the labor categories appear somewhat fuzzy as well.

The data also includes information on financial resources of each university; that is the shares of total budget financed by tuition fees, private funds and international public funds. However, the usefulness of these varies substantially, where tuition fees present the largest problem. Norway and Finland do not have any tuition fees and in the remaining countries, the process of raising fees is strongly regulated. As a consequence, there is little variation over time. This feature collides with the fact that this study utilizes the panel structure of the data to establish a credible identification strategy. Both public international funds and private funds contain enough variation over time to render the argument above irrelevant. However, we account for the universities third mission - technology transfer - only indirectly by including PhD students. To the extent that private principals target other channels

[1] see `http://www.prime-noe.org/index.php?project=prime&locale=en&level1=menu1_prime_1b8057d059a36720_21&level2=2&doc=Projects_Universities&page=2`

of technology transfer, our output distance function might not capture the impact of private funding appropriately.

The descriptive statistics are given in the Appendix. As can be seen from Table 1 both the outputs, inputs as well as the budget shares cover a wide range of data values with respect e.g. to country size (number of universities, number of students, labor inputs) and the political system of tertiary education (introduction of tuition fees, public and private budgets). Table 2 shows the cross-correlation between the variables and indicates that most of the inputs and outputs are correlated with each other. However, the analyzed budget shares show little evidence of correlation to the inputs and outputs. Exceptions are the share of tuition fees, which has a weak negative correlation and a correlation coefficient of .3 between private funding and publications. International public funds are not correlated to either inputs or outputs. Moreover, it is unrelated to the other budget shares as well, while private funding and tuition fees are negatively correlated. These findings are relevant to assess the problems of multi-collinearity and endogeneity. Based on the cross-correlations, these issues should not be that dramatic.

As quality data of the universities in our sample are not available as much as needed quality indicators could not be included in the analyzes. However, the quality of teaching and research of universities might be captured by fixed effects assuming that quality will probably not markedly change that much over a period of four years.

We manipulate the data in a number of ways: We interpolate all variables linearly. Moreover, we had to drop France, Germany and Hungary from the sample due to incomplete data. We also exclude all observations where data on the budget shares financed by international public grants or private funding are not available. We restrain from doing so for tuition fees as Norway and Finland do not have tuition fees which reflect the policy of the tertiary education system in these countries. Furthermore, we eliminate observations for which all outputs are missing. Finally, we replace outputs and inputs (and the budget share of tuition fees) by 0.01 (0.00001) to account for the logarithmic form of the distance function. However, our results are robust to the value of replacement. All variables are normalized by the median.

4 Results

Table 3 displays the results based on an OLS distance function regression including the share of budget financed by tuition fees, public international funds and private funds. These are included on the university level at first and then as an aggregation on the country level. This aggregation step helps to alleviate problems of endogeneity as the average budget shares are largely determined by politicians. The table further shows fixed effect estimators in columns 3 and 4. As before, the two distance functions vary in respect to the aggregation level of budget shares. The last column presents the estimates of a system GMM estimator including budget shares on the university level.

The coefficients are well-behaving for the OLS estimates in the sense that the first-order coefficients of outputs are negative and significant, while inputs are positive and significant. The fixed effects distance equations are somewhat less appropriate, though the direction of the impact is correctly estimated. The GMM results depict well-behaving outputs but misbehaving inputs, indicating that this estimation might be poorly specified. The estimations further contain country-specific dummy variables, where Switzerland is the base category. Furthermore, the OLS and fixed effects models contain country-specific trends. In respect to tuition, we find a positive significant coefficient for the OLS and FE equations that use university level budget shares, an insignificant result for country level budget shares and a negative result indicated by the GMM. The picture is clearer for public international funds, which are not significant in the OLS regressions but turn significantly negative in the fixed effects distance functions. Similarly, the GMM indicates a negative influence as well. Private funds remain insignificant in all estimations.

Table 4 shows the results of regressing the predicted fixed effects based on column 3 of Table 3 on a set of country dummies and the budget shares. The individual columns vary by the employed instrument. While column 2 uses the original values, columns 3 to 5 instrument contemporary budget shares by their 1 year, 2 years and 3 years lag. Similarly, column 6 uses country averages to instrumentalize budget shares. Budget shares financed by tuition fees and private funds do not appear to influence the efficiency of universities. Public international funds on the other hand have a significant positive impact on efficiency if the instrument is not lagged by too long. This finding is consistent with an interpretation that the competition for public international funds forces universities to increase efficiency. Note that lags 2 or longer, the significant impact disappears. This suggests that autocorrelation within budget shares might not be high. Therefore, this finding can be interpreted as good news in respect to the problem of endogeneity. However, over-identifying restriction tests reject the validity of the instruments.

The above estimations face the problem of simultaneity. We address this challenge in Table 5, where we identify inefficiency based on the assumption that inefficiencies are distributed half-normally. Based on Battese and Coelli (1995), we regress the predicted inefficiencies on budget shares in a simultaneous manner. As above, the columns of Table 5 differ by the instrument choice. However, as this estimator does not exist simultaneously, we estimate the first stage of the instrumental-variable approach manually and use these to predict budget shares and to insert these in the inefficiency equation. Bootstrapping the results helps to alleviate the non-simultaneity of the estimations.

Inspecting the results reveals well-behaving distance functions. In respect to the budget shares in the distance function, we find no impact of tuition and private funding on the production frontier, while public international funds have a negative impact. The lower part of Table 5 shows that inefficiencies are unaffected by private funds, positively affected by tuition fees and negatively affected by public international funds. These findings are consistent with those above, as the dependent variable has been efficiency in the two-stage approach presented above but inefficiency in the simultaneous estimator.

Battese and Coelli (1992) developed two panel data estimators: In the first, inefficiency is assumed time-invariant while it follows an exponential time trend in the latter. Table 6 depicts the results of these two estimators together with a pooled stochastic frontier that assumes no truncation of the inefficiency term, i.e. budget shares enter only the distance function directly. The distance functions of the panel estimators are not particularly well-behaving. Nevertheless, all three estimators indicate a negative correlation between budget shares and the production frontier. Table 7 portrays the corresponding results of the efficiency equation, revealing a positive impact of tuition fees and international public funding. The pooled and the time-varying panel frontier estimator allow inefficiencies to vary over time. Therefore, the interpretation of the panel estimator assuming time-invariant inefficiency is somewhat different, namely an influence on the level of inefficiency, while the other estimators may say something about variation over time as well. This is particularly relevant in respect to endogeneity. Assuming that endogeneity is stronger in levels than in differences, the problem of endogeneity is more worrisome in the case of time-invariant inefficiency.

Table 8 displays the regressions of predicted efficiencies based on the time-varying panel frontier on budget shares exploiting the presence of instruments. The results indicate a positive relationship of public international funds for the original values and up to 2 lags, but insignificant otherwise. Tuition tends to be positive too.

The dependent variable in Tables 9 and 10 is efficiency based on either the pooled frontier model or the time-varying panel frontier model. In these tables, we attempt to increase the stringency of controls even more. While Table 9 shows the results of a system GMM, Table 10 reports estimates that includes either a full set of fixed effects in the regression (see columns 2 and 4) or no individual components at all (columns 3 and 5). While the latter does not affect the results, using a GMM or fixed effects regression turns out to eliminate the significance of coefficients for budget shares. However, the insignificance of country-specific control variables suggests that the model might not be parsimonious, rendering a proper interpretation to be difficult.

Finally, Table 11 uses a simplified output distance function to estimate pooled frontiers for five countries: Italy, Netherlands, Portugal, Spain and the United Kingdom. While the small number of observations renders most distance functions problematic, the results indicate that our findings are not driven by a single country. This interpretation is supported by a set of regressions dropping a country at a time, revealing robust results.

5 Conclusion

We exploit a panel data set across eight European countries to explore the causal relationship between competitive university funding and productivity. We find mixed evidence in respect to tuition fees. Private funding appears unrelated to both the production frontier and efficiency. Public international funds on the other hand significantly reduce the production frontier, but also increase efficiency. This finding is in accordance with the hypothesis that competitive funding mechanisms reduce available resources due to monitoring costs, but increase competition between universities, thereby enhance efficiency.

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Appendix

Table 1: *Descriptive Statistics*

Variable	Obs	Mean	Std. Dev.	Min	Max
Total					
q1	2347	18111.29	21243.68	0	184350
q2	2091	906.9296	1040.726	0	10559
q3	2171	666.6472	914.7857	0	6543
x1	2325	340.2342	516.8687	0	3932
x2	2165	319.0083	327.9615	0	2342
x3	1812	612.9123	727.6172	0	7013
x4	2179	281.7342	383.6113	0	2504
x5	2333	884.73	801.1245	15	7185
bsha_tuit1	2194	0.1797148	.1020997 .	592	0.7042379
bsha_pub_int1	2399	0.020329	0.0287659	0	0.5498551
bsha_priv1	2399	0.0508786	0.0676603	0	0.4020464
Finland					
q1	160	7148.95	7012.158	208	32344
q2	160	1077.706	1262.84	8	5778
q3	120	502.2667	794.8445	0	3747
x1	160	109.4563	106.6427	4	475
x2	0				
x3	160	360.5313	436.1619	0	1984
x4	160	275.6625	261.6155	17	1177
x5	160	694.2625	811.8822	25	3759
bsha_tuit1	0				
bsha_pub_int1	160	0.0352147	0.0299931	0	0.1326203
bsha_priv1	160	0.180496	0.0689972	0.0176338	0.4019512
Italy					
q1	411	29953.18	28714.98	100	184350
q2	179	410.6704	412.5894	0	2095
q3	337	565.5282	577.7378	0	2866
x1	419	270.1026	257.2283	6	1444
x2	419	302.6659	272.9535	5	1389
x3	419	351.3389	338.0503	1	2065
x4	377	397.6499	415.0535	0	2504
x5	420	1071.421	1178.736	66	7185
bsha_tuit1	463	0.1109347	0.0483366	0.0000592	0.3318165
bsha_pub_int1	463	0.0079433	0.0326173	0	0.5498551
bsha_priv1	463	0.0393991	0.0444575	0	0.2595776
Netherlands					
q1	120	13469.09	5787.845	3740	26594
q2	120	397.0583	156.7408	128	786
q3	120	1653.55	801.5135	154	3614
x1	120	189.0583	73.65195	88	320
x2	120	191.2333	81.47152	72	406
x3	120	1164.208	500.3453	274	2268
x4	120	1287.358	445.2787	401	2183
x5	120	1564.658	604.9633	483	2798
bsha_tuit1	120	0.0543109	0.0211888	0.0137321	0.1739064
bsha_pub_int1	120	0.0184264	0.0176943	0	0.0987073
bsha_priv1	120	0.0901295	0.0463064	0	0.2365367
Norway					
q1	45	11767.71	10532.13	1606	35143
q2	21	55.80952	29.37111	10	102
q3	45	546.5778	585.1314	7	1959
x1	24	467	211.2633	161	800
x2	24	439.375	135.7347	226	693
x3	24	262.3333	98.9478	113	431
x4	24	675.4583	313.5825	229	1143
x5	24	384.625	252.1092	145	991
bsha_tuit1	0				
bsha_pub_int1	45	0.0143875	0.0085694	0.0001155	0.0331295
bsha_priv1	45	0.0394165	0.0326423	0.0013468	0.1463669
Portugal					
q1	70	10257.17	6831.306	1877	23055
q2	70	674.7246	601.1097	14.95116	2108.114
q3	70	281.5	283.5708	2	944
x1	70	76.04286	74.08523	3	215
x2	70	118.8143	106.7044	5	389
x3	70	257.6429	218.7996	21	761
x4	70	487.4857	289.7597	138	1056

Variable	Obs	Mean	Std. Dev.	Min	Max
Total					
x5	70	632.8286	445.9628	102	1433
bsha_tuit1	70	0.0527236	0.025404	0.0011267	0.1202999
bsha_pub_int1	70	0.0694642	0.0451896	0.0113381	0.2323929
bsha_priv1	70	0.2261399	0.0716107	0.104706	0.3894713
Spain					
q1	513	30563.79	25381.9	298	146330
q2	513	1316.111	1280.571	0	10559
q3	513	382.1676	386.9228	0	2250
x1	513	991.345	747.277	12	3932
x2	513	603.3431	396.9402	0	2342
x3	0				
x4	512	171.2324	191.8007	0	1605
x5	513	853.5185	625.3121	46	3563
bsha_tuit1	513	0.1877321	0.0691517	0.0247243	0.588671
bsha_pub_int1	513	0.0305753	0.0314007	0	0.2018694
bsha_priv1	513	0.012073	0.0130734	0	0.1019891
Switzerland					
q1	105	6760.105	4448.253	164	19932
q2	105	1126.181	786.8955	0	3171
q3	72	1283.486	724.5352	185	2562
x1	103	238.9709	122.7026	16	401
x2	103	535.5728	481.5319	26	2024
x3	103	1928.796	1665.197	15	7013
x4	0				
x5	103	1111.068	891.1526	18	3362
bsha_tuit1	105	0.033132	0.0338876	0.0067675	0.174845
bsha_pub_int1	105	0.0124514	0.0215478	0	0.1337236
bsha_priv1	105	0.0841589	0.0901521	0	0.4020464
United Kingdom					
q1	923	10617.25	12250.3	0	141635
q2	923	824.467	961.1804	0	6258
q3	894	744.123	1163.429	0	6543
x1	916	96.03344	105.2618	0	628
x2	916	171.7763	161.6422	0	1178
x3	916	592.7937	571.4389	0	3610
x4	916	139.0718	199.4585	0	2300
x5	923	768.5948	629.3424	15	4024
bsha_tuit1	923	0.2523708	0.085548	0.0919563	0.7042379
bsha_pub_int1	923	0.0159734	0.0167875	0	0.187404
bsha_priv1	923	0.0341143	0.0400764	0	0.1866709

Table 2: *Cross-correlations between variables*

	q1	q2	q3	x1	x2	x3	x4	x5	bsha_tuition	bsha_int_public
q1	1									
q2	0.5183	1								
q3	0.1546	0.6026	1							
x1	0.6482	0.5999	0.1446	1						
x2	0.6246	0.6993	0.3176	0.8097	1					
x3	0.1886	0.6297	0.7158	0.471	0.5824	1				
x4	0.2224	0.1705	0.4536	0.1212	0.1521	0.3839	1			
x5	0.619	0.6877	0.6493	0.4357	0.6135	0.6419	0.4992	1		
Bsha_Tuition	0.0426	-0.0628	-0.2816	-0.0467	-0.1608	-0.2763	-0.4059	-0.223	1	
Bsha_Int_Public	-0.0803	0.122	0.0688	0.0551	0.0404	0.0481	-0.0234	-0.0168	-0.1171	1
Bsha_Private	-0.1975	0.1427	0.3014	-0.196	-0.0832	0.1115	0.2731	0.079	-0.4123	0.2539

Table 3: *OLS, Fixed Effects and GMM Output Distance Functions for budget shares on university and country level*

	OLS uni	OLS coun	FE uni	FE coun	GMM 1
lq2	-0.377***	-0.379***	-0.315***	-0.314***	-0.074**
	(0.018)	(0.014)	(0.069)	(0.071)	(0.032)
lq3	-0.108***	-0.132***	-0.037	-0.054**	-0.313***
	(0.008)	(0.007)	(0.029)	(0.021)	(0.040)
q2q2	-0.061***	-0.058***	-0.051***	-0.049***	-0.012**
	(0.004)	(0.005)	(0.012)	(0.012)	(0.006)
q3q3	-0.013***	-0.012***	-0.003	-0.003	-0.058***
	(0.001)	(0.001)	(0.005)	(0.004)	(0.007)
q2q3	0.005**	0.004*	0.005***	0.004***	0.004***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
lx1	0.234***	0.245**	0.131*	0.121	0.038
	(0.066)	(0.076)	(0.079)	(0.082)	(0.052)
lx2	0.202***	0.202***	0.265***	0.262***	0.095*
	(0.050)	(0.049)	(0.064)	(0.067)	(0.053)
lx3	0.298***	0.279***	0.250***	0.236***	0.097
	(0.040)	(0.044)	(0.083)	(0.076)	(0.076)
lx4	0.048**	0.054***	0.054***	0.056***	0.002
	(0.016)	(0.014)	(0.019)	(0.019)	(0.016)
lx5	0.191***	0.177***	0.268***	0.268***	0.080
	(0.031)	(0.033)	(0.025)	(0.031)	(0.089)
x1x1	0.042**	0.044**	0.024**	0.022*	0.013
	(0.013)	(0.015)	(0.012)	(0.013)	(0.021)
x2x2	0.025*	0.023	0.046	0.045	0.029**
	(0.013)	(0.018)	(0.031)	(0.031)	(0.015)
x3x3	0.061***	0.061***	0.045***	0.045***	0.048**
	(0.007)	(0.007)	(0.015)	(0.014)	(0.019)
x4x4	0.015**	0.012	0.018***	0.017***	0.015**
	(0.005)	(0.007)	(0.005)	(0.005)	(0.006)
x5x5	-0.053	-0.051	-0.120	-0.120	0.079
	(0.111)	(0.107)	(0.125)	(0.115)	(0.079)
x1x3	0.015	0.016	0.007	0.006	0.007
	(0.013)	(0.014)	(0.012)	(0.011)	(0.020)
x1x4	0.005	0.009*	0.002	0.005	-0.009*
	(0.006)	(0.004)	(0.007)	(0.006)	(0.005)
x1x5	-0.039*	-0.047*	-0.013	-0.012	-0.001
	(0.017)	(0.021)	(0.043)	(0.044)	(0.026)
x2x3	0.006	0.007	0.009	0.008	0.003
	(0.007)	(0.008)	(0.015)	(0.015)	(0.006)
x2x4	-0.001	-0.007	0.004	0.002	0.037***
	(0.004)	(0.004)	(0.012)	(0.012)	(0.008)
x2x5	-0.011	-0.008	-0.010	-0.009	-0.052**
	(0.012)	(0.014)	(0.019)	(0.020)	(0.023)
x3x4	-0.005	-0.003	-0.004	-0.003	-0.002
	(0.003)	(0.003)	(0.003)	(0.004)	(0.002)
x3x5	0.045	0.044	0.062	0.059	-0.017
	(0.047)	(0.044)	(0.045)	(0.040)	(0.017)
x4x5	0.057***	0.062***	0.062***	0.061***	0.002
	(0.005)	(0.006)	(0.006)	(0.007)	(0.009)
x1q2	0.002	0.002	0.008**	0.008***	-0.009**
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
x1q3	-0.009**	-0.012**	-0.008	-0.009	-0.001
	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
x2q2	-0.026**	-0.023*	-0.030***	-0.027***	0.004
	(0.010)	(0.010)	(0.005)	(0.004)	(0.008)
x2q3	-0.006***	-0.009***	-0.003***	-0.005***	-0.005***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
x3q1	-0.096*	-0.101*	-0.086*	-0.087**	-0.062***
	(0.045)	(0.045)	(0.044)	(0.044)	(0.017)
x3q2	-0.011***	-0.014***	-0.010***	-0.011***	-0.004
	(0.001)	(0.001)	(0.003)	(0.003)	(0.004)
x3q3	-0.009	-0.009	-0.009	-0.008	0.003
	(0.009)	(0.009)	(0.008)	(0.007)	(0.005)
x4q1	-0.082***	-0.085***	-0.084***	-0.086***	-0.031***
	(0.002)	(0.002)	(0.009)	(0.008)	(0.009)
x4q2	-0.010**	-0.013***	-0.009***	-0.010***	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
x4q3	-0.007***	-0.009**	-0.003**	-0.004***	-0.007***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
x5q1	0.057	0.058	0.041	0.042	-0.005
	(0.044)	(0.044)	(0.049)	(0.049)	(0.048)
x5q2	0.016**	0.017**	0.011	0.009	-0.000
	(0.006)	(0.005)	(0.010)	(0.010)	(0.010)

	OLS uni	OLS coun	FE uni	FE coun	GMM 1
x5q3	0.010	0.013	0.010	0.012	0.003
	(0.015)	(0.017)	(0.015)	(0.015)	(0.010)
Finland	2.451**	0.025	1.598	0.233	1.248
	(1.022)	(1.105)	(1.346)	(0.959)	(5.709)
Italy	0.963***	1.539***	0.938***	1.185***	2.509
	(0.208)	(0.195)	(0.251)	(0.286)	(5.806)
Netherlands	-0.506**	-0.739*	-0.310	-0.473	6.764
	(0.171)	(0.318)	(0.359)	(0.387)	(8.288)
Norway	1.533*	-0.566	1.109**	-0.001	-9.787
	(0.659)	(0.862)	(0.543)	(0.342)	(13.250)
Portugal	0.968***	0.712	1.160***	0.919***	-0.190
	(0.242)	(0.522)	(0.251)	(0.309)	(4.089)
Spain	-0.278	0.435	0.581	0.869	0.819
	(1.006)	(0.949)	(0.843)	(0.780)	(6.086)
United Kingdom	0.251	0.871***	0.379	0.613	1.723
	(0.189)	(0.118)	(0.420)	(0.408)	(6.478)
Trend_Finland	0.023	0.047**	0.020*	0.033***	
	(0.014)	(0.018)	(0.010)	(0.012)	
Trend_Italy	-0.143***	-0.266***	-0.078***	-0.147***	
	(0.025)	(0.037)	(0.019)	(0.015)	
Trend_Netherlands	0.034***	0.094**	0.032***	0.062***	
	(0.004)	(0.032)	(0.003)	(0.011)	
Trend_Norway	-0.057	-0.122**	-0.055***	-0.090***	
	(0.033)	(0.050)	(0.014)	(0.014)	
Trend_Portugal	-0.054**	0.041	-0.040	0.014	
	(0.020)	(0.030)	(0.032)	(0.018)	
Trend_Spain	0.020	-0.000	0.012	0.001	
	(0.013)	(0.008)	(0.009)	(0.008)	
Trend_Switzerland	-0.030	-0.051**	-0.001	-0.024**	
	(0.020)	(0.019)	(0.003)	(0.011)	
Trend_United Kingdom	-0.021***	-0.022***	-0.007***	-0.006**	
	(0.002)	(0.003)	(0.002)	(0.003)	
Bsha Tuition	0.201**		0.131**		-0.050*
	(0.059)		(0.056)		(0.027)
Bsha Int Public	-0.007		-0.011***		-0.004*
	(0.006)		(0.004)		(0.002)
Bsha Private	0.007		-0.010		0.006
	(0.021)		(0.009)		(0.006)
Bsha Tuition Average		-0.079		-0.016	
		(0.109)		(0.054)	
Bsha Int Public Average		-0.322		-0.184***	
		(0.172)		(0.066)	
Bsha Private Average		0.183		0.079	
		(0.099)		(0.049)	
L.lq1					0.087***
					(0.028)
Constant	-0.194	-0.666***	-0.593***	-0.762***	-2.080
	(0.147)	(0.140)	(0.223)	(0.228)	(5.804)
N	2399.000	2399.000	2399.000	2399.000	2103.000
Wald chi2			.	.	1220.842
Prob ¿ chi2	.	.	.	.	0.000

The table displays coefficients, robust standard errors, which are ;
clustered at the country level, are shown in parentheses;
*, ** and *** denote significance levels 10%, 5% and 1%
Column 2: OLS including budget shares at institution level
Column 3: OLS including budget shares at country level
Column 4: Fixed effect model including budget shares at institution level
Column 5: Fixed effect model including budget shares at country level
Column 6: GMM estimator including budget shares at institution level

Table 4: *Regression of Estimated Fixed Effects on Budget Shares*

	No Instrument	1 Year Lag	2 Year Lag	3 Year Lag	Country Average
Finland	5.908***	4.979	-37.252	-51.788	-2.628
	(1.342)	(5.403)	(1974.584)	(164.894)	(5.110)
Italy	-1.259***	-1.067	6.534	8.792	-0.463
	(0.332)	(1.098)	(368.534)	(30.385)	(1.300)
Netherlands	0.197	0.391	5.299	6.575	-3.458***
	(0.193)	(0.655)	(227.762)	(19.443)	(1.013)
Norway	6.543***	5.488	-37.834	-51.972	2.545
	(1.345)	(5.522)	(2028.417)	(168.662)	(4.934)
Portugal	-0.428*	-0.199	4.317	6.179	-8.928***
	(0.231)	(0.648)	(154.387)	(18.676)	(1.608)
Spain	-0.225	-0.046	10.298	15.536	0.641
	(0.373)	(1.435)	(471.033)	(42.769)	(1.653)
United Kingdom	-1.826***	-1.566	10.738	15.784	-0.828
	(0.413)	(1.649)	(571.401)	(49.582)	(1.784)
Bsha Tuition	0.818***	0.680	-4.900	-6.803	0.632
	(0.173)	(0.717)	(260.812)	(21.855)	(0.609)
Bsha Int Public	0.110***	0.122**	0.179	-0.316	0.806***
	(0.032)	(0.050)	(4.441)	(0.722)	(0.183)
Bsha Private	0.051	-0.026	-0.675	-0.299	2.477***
	(0.034)	(0.086)	(32.192)	(2.247)	(0.603)
Constant	0.852**	0.591	-10.201	-14.781	2.553*
	(0.364)	(1.454)	(499.740)	(43.592)	(1.386)
N	2399.000	2399.000	2399.000	2399.000	2399.000
Wald chi2	1461.076	1980.810	56.559	81.087	147.326
Prob ¿ chi2	0.000	0.000	0.000	0.000	0.000

The table displays coefficients, bootstrapped standard errors are in parentheses;
*, ** and *** denote significance levels 10%, 5% and 1%
Column 2: Budget shares are not instrumented
Column 3: Budget shares are instrumented using a one year lag
Column 4: Budget shares are instrumented using a two year lag
Column 5: Budget shares are instrumented using a three year lag
Column 6: Budget shares are instrumented using country averages

Table 5: *Pooled Stochastic Frontier and Simultaneous Regression of Inefficiency on Budget Shares*

	No Instrument	1 Year Lag	2 Year Lag	3 Year Lag	Country Average
lq2	-0.387***	-0.379***	-0.379***	-0.360***	-0.364***
	(0.050)	(0.042)	(0.031)	(0.029)	(0.029)
lq3	-0.156***	-0.156***	-0.154***	-0.153***	-0.131***
	(0.029)	(0.022)	(0.020)	(0.028)	(0.022)
q2q2	-0.060***	-0.057***	-0.060***	-0.054***	-0.052***
	(0.012)	(0.010)	(0.009)	(0.010)	(0.006)
q3q3	-0.025***	-0.022***	-0.021***	-0.021***	-0.015***
	(0.007)	(0.004)	(0.004)	(0.005)	(0.003)
q2q3	0.014**	0.012***	0.012***	0.009**	0.005
	(0.006)	(0.004)	(0.004)	(0.004)	(0.005)
lx1	0.356***	0.334***	0.339***	0.315***	0.286***
	(0.063)	(0.039)	(0.042)	(0.047)	(0.029)
lx2	0.110***	0.112***	0.107***	0.120***	0.126***
	(0.032)	(0.025)	(0.025)	(0.028)	(0.026)
lx3	0.303***	0.300***	0.307***	0.285***	0.264***
	(0.037)	(0.042)	(0.025)	(0.027)	(0.027)
lx4	0.018	0.033**	0.035*	0.039**	0.052***
	(0.016)	(0.015)	(0.019)	(0.016)	(0.016)
lx5	0.161*	0.169**	0.158**	0.197***	0.212***
	(0.086)	(0.077)	(0.075)	(0.075)	(0.046)
x1x1	0.068***	0.063***	0.064***	0.058***	0.052***
	(0.016)	(0.011)	(0.011)	(0.013)	(0.008)
x2x2	-0.000	0.002	0.004	0.004	0.007
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
x3x3	0.056***	0.057***	0.061***	0.052***	0.052***
	(0.008)	(0.009)	(0.007)	(0.011)	(0.007)
x4x4	0.009*	0.010*	0.010**	0.010	0.012*

	No Instrument	1 Year Lag	2 Year Lag	3 Year Lag	Country Average
	(0.005)	(0.006)	(0.004)	(0.006)	(0.006)
x5x5	0.115***	0.103***	0.105***	0.083**	0.083**
	(0.044)	(0.036)	(0.038)	(0.035)	(0.037)
x1x3	0.029***	0.025***	0.022***	0.022***	0.013*
	(0.009)	(0.006)	(0.006)	(0.006)	(0.008)
x1x4	-0.003	0.006	0.009	0.008	0.017**
	(0.005)	(0.004)	(0.006)	(0.005)	(0.007)
x1x5	-0.085***	-0.083***	-0.087***	-0.071***	-0.068***
	(0.026)	(0.020)	(0.022)	(0.019)	(0.017)
x2x3	0.008**	0.007***	0.005*	0.007**	0.006**
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
x2x4	-0.004	-0.007*	-0.008	-0.006	-0.007*
	(0.008)	(0.004)	(0.005)	(0.004)	(0.004)
x2x5	-0.016	-0.013*	-0.011	-0.011	-0.013
	(0.011)	(0.007)	(0.011)	(0.010)	(0.009)
x3x4	-0.005***	-0.003*	-0.003*	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
x3x5	0.001	0.001	0.001	0.006	0.008
	(0.015)	(0.011)	(0.011)	(0.012)	(0.007)
x4x5	0.047***	0.050***	0.049***	0.048***	0.047***
	(0.014)	(0.010)	(0.009)	(0.012)	(0.007)
x1q2	-0.005	-0.009	-0.008	-0.010	-0.005
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
x1q3	-0.005	-0.003	-0.005	-0.002	-0.005
	(0.004)	(0.005)	(0.004)	(0.007)	(0.006)
x2q2	-0.010	-0.006	-0.006	-0.008	-0.007
	(0.008)	(0.009)	(0.011)	(0.011)	(0.009)
x2q3	-0.004***	-0.006***	-0.007***	-0.007***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
x3q1	-0.076***	-0.073***	-0.070***	-0.073***	-0.066***
	(0.013)	(0.006)	(0.006)	(0.008)	(0.007)
x3q2	-0.019***	-0.017***	-0.016***	-0.017***	-0.015***
	(0.005)	(0.003)	(0.004)	(0.004)	(0.005)
x3q3	-0.012***	-0.010***	-0.009***	-0.009*	-0.006*
	(0.004)	(0.003)	(0.003)	(0.005)	(0.004)
x4q1	-0.059***	-0.068***	-0.069***	-0.070***	-0.080***
	(0.017)	(0.012)	(0.012)	(0.018)	(0.008)
x4q2	-0.007***	-0.008***	-0.009***	-0.009**	-0.012***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
x4q3	-0.003	-0.006***	-0.006***	-0.006***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
x5q1	0.040**	0.039***	0.035***	0.038***	0.031***
	(0.017)	(0.011)	(0.011)	(0.014)	(0.008)
x5q2	0.016	0.014	0.011	0.018*	0.011
	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
x5q3	0.004	0.004	0.006	0.002	0.004
	(0.007)	(0.007)	(0.006)	(0.008)	(0.009)
Finland	0.934	1.424	-1.426	15.229*	0.007
	(1.292)	(1.028)	(3.384)	(8.643)	(0.731)
Italy	0.448	0.791	1.533*	-1.622	1.031
	(0.406)	(0.516)	(0.852)	(1.460)	(0.632)
Netherlands	-0.582**	-0.514**	-0.193	-2.059**	-0.577*
	(0.293)	(0.244)	(0.421)	(0.987)	(0.302)
Norway	-0.845	-0.367	-2.779	13.911	-1.265*
	(1.324)	(1.040)	(3.481)	(8.959)	(0.663)
Portugal	0.309	0.533*	0.873**	-0.806	0.544*
	(0.393)	(0.284)	(0.428)	(0.909)	(0.297)
Spain	0.268	0.249	0.679	-2.784	0.619
	(0.390)	(0.364)	(0.903)	(1.979)	(0.445)
United Kingdom	0.709	0.781*	1.531	-3.181	1.182***
	(0.464)	(0.414)	(1.011)	(2.508)	(0.373)
Trend_Finland	0.022	0.019	0.012	0.016	0.032***
	(0.015)	(0.013)	(0.015)	(0.027)	(0.010)
Trend_Italy	-0.022	-0.046	-0.091	-0.063	-0.063
	(0.076)	(0.059)	(0.066)	(0.076)	(0.055)
Trend_Netherlands	0.040***	0.029***	0.024***	0.024***	0.057***
	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
Trend_Norway	-0.021	-0.028	-0.045*	-0.047	-0.059**
	(0.028)	(0.024)	(0.025)	(0.033)	(0.023)
Trend_Portugal	0.031	0.017	-0.000	0.007	0.036*
	(0.047)	(0.018)	(0.017)	(0.016)	(0.020)
Trend_Spain	0.004	0.004	0.003	-0.001	-0.003
	(0.006)	(0.003)	(0.003)	(0.005)	(0.005)
Trend_Switzerland	-0.040**	-0.025**	-0.025**	-0.019**	-0.022
	(0.020)	(0.011)	(0.013)	(0.009)	(0.014)

	No Instrument	1 Year Lag	2 Year Lag	3 Year Lag	Country Average
Trend_United Kingdom	-0.024**	-0.025***	-0.031***	-0.015*	-0.015**
	(0.010)	(0.007)	(0.008)	(0.008)	(0.006)
Bsha Tuition	-0.034	0.018	-0.323	1.839	-0.112*
	(0.140)	(0.121)	(0.438)	(1.132)	(0.066)
Bsha Int Public	-0.026***	-0.023***	-0.035***	-0.125***	-0.080***
	(0.008)	(0.007)	(0.011)	(0.045)	(0.021)
Bsha Private	-0.008	0.005	-0.036	0.279*	0.069
	(0.008)	(0.015)	(0.044)	(0.144)	(0.051)
Constant	-0.138	-0.228	-0.896	3.143	-0.679*
	(0.301)	(0.351)	(0.877)	(2.158)	(0.347)
lnsig2v					
Constant	-3.643	-3.625**	-3.435**	-3.640*	-3.316***
	(2.248)	(1.624)	(1.525)	(2.048)	(0.309)
Inefficiency					
Finland	-6.337	7.923**	-23.641	14.962	-39.311*
	(9.754)	(3.179)	(19.128)	(9.618)	(21.301)
Italy	-1.228	0.327	0.418	-1.418	3.589
	(3.464)	(0.380)	(0.427)	(1.851)	(2.397)
Netherlands	-4.837	-6.812	-4.074	-4.609	-16.335
	(2.972)	(10.134)	(5.264)	(6.009)	(9.957)
Norway	-7.638	5.532	4.508	7.913	-41.185*
	(10.914)	(10.514)	(11.787)	(10.024)	(21.560)
Portugal	-29.632***	-3.393*	-9.456	-4.044**	-14.748*
	(10.968)	(1.799)	(7.715)	(1.900)	(7.821)
Spain	-7.550	-28.542***	-11.173**	-8.125***	-9.111***
	(6.116)	(9.957)	(5.227)	(1.400)	(3.270)
United Kingdom	-1.673	-1.985***	-2.308***	-2.300**	-0.988
	(2.462)	(0.583)	(0.583)	(1.047)	(2.032)
Bsha Tuition	-0.410	1.088***	1.029***	2.005**	4.852
	(1.791)	(0.257)	(0.333)	(0.949)	(3.376)
Bsha Int Public	-0.131**	-0.145*	-0.018	-1.066**	0.269
	(0.058)	(0.086)	(0.111)	(0.487)	(0.316)
Bsha Private	-0.154	-0.013	-0.379*	1.095	2.391***
	(0.147)	(0.157)	(0.203)	(0.878)	(0.675)
Constant	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	2399.000	2399.000	2399.000	2399.000	2399.000
Wald chi2	725206.820	626450.405	269616.077	505051.085	722035.519
Prob ¿ chi2	0.000	0.000	0.000	0.000	0.000

The table displays coefficients, bootstrapped standard errors are in parentheses;
*, ** and *** denote significance levels 10%, 5% and 1%
Column 2: Budget share are not instrumented
Column 3: Budget share are instrumented using a one year lag
Column 4: Budget share are instrumented using a two year lag
Column 5: Budget share are instrumented using a three year lag
Column 6: Budget share are instrumented using country averages

Table 6: *Panel Data Stochastic Frontier Estimates*

	Pooled SFA	Panel SFA, Constant	Panel SFA, Varying
lq2	-0.375***	-0.072	-0.074
	(0.023)	(0.067)	(0.101)
lq3	-0.130***	-0.052*	-0.059**
	(0.024)	(0.030)	(0.028)
q2q2	-0.060***	-0.010	-0.010
	(0.005)	(0.011)	(0.016)
q3q3	-0.018***	-0.009	-0.010*
	(0.004)	(0.006)	(0.005)
q2q3	0.014***	0.005	0.005
	(0.005)	(0.005)	(0.005)
lx1	0.329***	0.102**	0.088*
	(0.033)	(0.042)	(0.049)
lx2	0.157***	0.171**	0.179***
	(0.038)	(0.079)	(0.061)
lx3	0.137***	0.100*	0.106**
	(0.042)	(0.052)	(0.051)
lx4	0.021	0.005	0.006
	(0.017)	(0.015)	(0.021)
lx5	0.264***	0.257***	0.252***
	(0.052)	(0.056)	(0.058)
x1x1	0.063***	0.018**	0.016*

	Pooled SFA	Panel SFA, Constant	Panel SFA, Varying
	(0.007)	(0.007)	(0.009)
x2x2	0.023*	0.032*	0.033*
	(0.013)	(0.018)	(0.019)
x3x3	0.027**	0.027**	0.030**
	(0.011)	(0.012)	(0.013)
x4x4	0.010	0.009	0.009
	(0.006)	(0.009)	(0.010)
x5x5	0.095*	-0.082	-0.087
	(0.053)	(0.066)	(0.073)
x1x3	0.014*	-0.004	-0.004
	(0.007)	(0.010)	(0.011)
x1x4	0.006	0.000	-0.000
	(0.007)	(0.008)	(0.007)
x1x5	-0.094***	0.003	0.005
	(0.015)	(0.026)	(0.028)
x2x3	0.007	0.006	0.006
	(0.004)	(0.009)	(0.007)
x2x4	-0.003	0.012	0.012
	(0.006)	(0.027)	(0.020)
x2x5	-0.018	-0.013	-0.013
	(0.012)	(0.033)	(0.032)
x3x4	-0.006**	-0.005	-0.005
	(0.002)	(0.004)	(0.003)
x3x5	0.032***	0.035***	0.035**
	(0.012)	(0.012)	(0.014)
x4x5	0.052***	0.055*	0.053*
	(0.012)	(0.028)	(0.027)
x1q2	-0.002	0.005	0.005
	(0.009)	(0.006)	(0.005)
x1q3	-0.005	-0.004	-0.004
	(0.005)	(0.003)	(0.003)
x2q2	-0.019	-0.012	-0.014*
	(0.012)	(0.008)	(0.008)
x2q3	-0.005***	-0.002	-0.002
	(0.001)	(0.001)	(0.001)
x3q1	-0.077***	-0.046**	-0.053***
	(0.012)	(0.021)	(0.020)
x3q2	-0.014***	-0.004	-0.004
	(0.004)	(0.007)	(0.007)
x3q3	-0.007*	-0.007*	-0.006
	(0.004)	(0.004)	(0.004)
x4q1	-0.077***	-0.077**	-0.074**
	(0.011)	(0.030)	(0.033)
x4q2	-0.011***	-0.007*	-0.007*
	(0.003)	(0.004)	(0.004)
x4q3	-0.003*	-0.002	-0.002
	(0.002)	(0.001)	(0.002)
x5q1	0.040***	0.004	0.010
	(0.014)	(0.040)	(0.037)
x5q2	0.016	-0.001	0.001
	(0.015)	(0.010)	(0.009)
x5q3	0.000	0.007	0.006
	(0.009)	(0.009)	(0.008)
Finland	0.285	1.226	1.067
	(0.818)	(1.053)	(1.168)
Italy	0.941*	1.190***	1.157
	(0.513)	(0.337)	(0.824)
Netherlands	-0.264	0.431*	0.411
	(0.307)	(0.254)	(0.786)
Norway	-0.097	1.576**	1.412
	(0.614)	(0.695)	(0.976)
Portugal	0.598	1.053***	0.996
	(0.364)	(0.352)	(0.797)
Spain	-0.070	1.130	0.814
	(0.625)	(1.027)	(1.157)
United Kingdom	0.771**	1.710***	1.577*
	(0.335)	(0.591)	(0.844)
Trend_Finland	0.034***	0.030**	0.047***
	(0.011)	(0.013)	(0.014)
Trend_Italy	-0.107**	0.006	0.013
	(0.050)	(0.017)	(0.015)
Trend_Netherlands	0.032***	0.024***	0.031***
	(0.011)	(0.007)	(0.011)
Trend_Norway	-0.077**	-0.040***	-0.028
	(0.031)	(0.014)	(0.032)
Trend_Portugal	0.024	-0.011	-0.002

	Pooled SFA	Panel SFA, Constant	Panel SFA, Varying
	(0.040)	(0.019)	(0.017)
Trend_Spain	0.014**	-0.006	0.007
	(0.005)	(0.010)	(0.009)
Trend_Switzerland	-0.033**	0.001	0.007
	(0.013)	(0.010)	(0.024)
Trend_United Kingdom	-0.017	0.008	0.031*
	(0.012)	(0.007)	(0.017)
Bsha Tuition	-0.014	0.053	0.047
	(0.076)	(0.034)	(0.035)
Bsha Int Public	-0.019***	-0.009*	-0.010**
	(0.007)	(0.005)	(0.005)
Bsha Private	-0.008	-0.005	-0.004
	(0.011)	(0.004)	(0.004)
Constant	0.054	-0.377	-0.388
	(0.327)	(0.292)	(0.782)
lnsig2v			
Constant	-3.921		
	(3.837)		
Inefficiency			
Constant	0.000		
	(0.000)		
lnsigma2			
Constant		1.271***	1.311*
		(0.471)	(0.705)
ilgtgamma			
Constant		4.677***	4.730***
		(0.763)	(1.070)
mu			
Constant		0.000	0.000
		(0.000)	(0.000)
eta			
Constant			-0.012
			(0.014)
N	2399.000	2399.000	2399.000
Wald chi2	1217787.830	58978.776	671988.269
Prob ¿ chi2	0.000	0.000	0.000

The table displays coefficients, standard errors are in parentheses;
Standard errors are bootstrapped in the simple stochastic frontiers.
*, ** and *** denote significance levels 10%, 5% and 1%
Column 2: Pooled stochastic frontier allowing inefficiency to vary freely over time
Column 3: Panel stochastic frontier assuming time-invariant inefficiency
Column 4: Panel stochastic frontier assuming time-varying inefficiency

Table 7: *Regressions of Estimated Technical Efficiencies on Budget Shares*

	Pooled SFA	Panel SFA, Constant	Panel SFA, Varying
Finland	0.223*	0.342	0.324*
	(0.104)	(0.184)	(0.169)
Italy	-0.097***	-0.193***	-0.195***
	(0.027)	(0.032)	(0.035)
Netherlands	-0.069**	-0.103***	-0.129***
	(0.028)	(0.016)	(0.024)
Norway	0.022	0.397*	0.596***
	(0.108)	(0.183)	(0.170)
Portugal	-0.033	-0.137***	-0.034
	(0.035)	(0.014)	(0.033)
Spain	-0.033	-0.500***	-0.479***
	(0.030)	(0.045)	(0.046)
United Kingdom	-0.144***	-0.653***	-0.679***
	(0.036)	(0.052)	(0.052)
Trend_Finland	-0.006***		-0.005***
	(0.000)		(0.000)
Trend_Italy	-0.005***		-0.009***
	(0.000)		(0.001)
Trend_Netherlands	0.005**		-0.005**
	(0.001)		(0.002)
Trend_Norway	0.017***		-0.035***
	(0.001)		(0.001)
Trend_Portugal	-0.005		-0.030***
	(0.005)		(0.007)
Trend_Spain	-0.002***		-0.004***
	(0.000)		(0.000)
Trend_Switzerland	-0.002		-0.011***
	(0.003)		(0.002)
Trend_United Kingdom	-0.001**		-0.003***
	(0.000)		(0.000)
Bsha Tuition	0.028*	0.080**	0.080***
	(0.013)	(0.023)	(0.022)
Bsha Int Public	0.004	0.008**	0.007*
	(0.002)	(0.003)	(0.003)
Bsha Private	0.012**	-0.003	-0.001
	(0.004)	(0.003)	(0.003)
Constant	0.735***	0.838***	0.884***
	(0.034)	(0.043)	(0.044)
N	2399.000	2399.000	2399.000
Wald chi2			
Prob ¿ chi2	.	.	.

The table displays coefficients, standard errors are in parentheses;
Standard errors are robust and clustered at the country level.
*, ** and *** denote significance levels 10%, 5% and 1%
Column 2: Pooled stochastic frontier allowing inefficiency to vary freely over time
Column 3: Panel stochastic frontier assuming time-invariant inefficiency
Column 4: Panel stochastic frontier assuming time-varying inefficiency

Table 8: *Instrumental Variable Approach Regressions of Estimated Technical Efficiencies on Budget Shares*

	No Instrument	1 Year Lag	2 Year Lag	3 Year Lag	Country Average
Finland	0.324*	0.340	0.353	0.185	-0.335
	(0.169)	(0.208)	(0.565)	(0.947)	(0.410)
Italy	-0.195***	-0.197***	-0.198	-0.126	-0.106
	(0.035)	(0.063)	(0.142)	(0.278)	(0.158)
Netherlands	-0.129***	-0.126**	-0.118	-0.022	-0.113
	(0.024)	(0.062)	(0.113)	(0.251)	(0.219)
Norway	0.596***	0.607**	0.610	0.387	-0.036
	(0.170)	(0.273)	(0.548)	(1.011)	(0.425)
Portugal	-0.034	-0.033	-0.033	-0.028	-0.189
	(0.033)	(0.078)	(0.081)	(0.111)	(0.235)
Spain	-0.479***	-0.484***	-0.491***	-0.425	-0.345**
	(0.046)	(0.076)	(0.181)	(0.326)	(0.170)
United Kingdom	-0.679***	-0.683***	-0.686***	-0.594	-0.526***
	(0.052)	(0.081)	(0.209)	(0.387)	(0.194)
Trend_Finland	-0.005***	-0.005	-0.005	-0.007	-0.005
	(0.000)	(0.007)	(0.007)	(0.006)	(0.007)
Trend_Italy	-0.009***	-0.009**	-0.008*	-0.006	-0.011**
	(0.001)	(0.004)	(0.004)	(0.005)	(0.006)
Trend_Netherlands	-0.005**	-0.005	-0.007	-0.012	-0.006
	(0.002)	(0.005)	(0.006)	(0.011)	(0.007)
Trend_Norway	-0.035***	-0.035	-0.034	-0.031	-0.036
	(0.001)	(0.027)	(0.024)	(0.026)	(0.027)
Trend_Portugal	-0.030***	-0.030*	-0.031	-0.020	-0.004
	(0.007)	(0.017)	(0.027)	(0.049)	(0.023)
Trend_Spain	-0.004***	-0.004***	-0.004**	-0.004**	-0.006*
	(0.000)	(0.001)	(0.002)	(0.002)	(0.003)
Trend_Switzerland	-0.011***	-0.011*	-0.010	-0.002	-0.017
	(0.002)	(0.006)	(0.010)	(0.019)	(0.028)
Trend_United Kingdom	-0.003***	-0.003*	-0.003**	-0.003*	-0.004
	(0.000)	(0.002)	(0.002)	(0.002)	(0.003)
Bsha Tuition	0.080***	0.082***	0.083	0.053	0.003
	(0.022)	(0.029)	(0.075)	(0.138)	(0.054)
Bsha Int Public	0.007*	0.008***	0.010**	0.019	0.010
	(0.003)	(0.002)	(0.004)	(0.013)	(0.009)
Bsha Private	-0.001	-0.002	-0.003	-0.016	0.010
	(0.003)	(0.004)	(0.008)	(0.024)	(0.043)
Constant	0.884***	0.888***	0.892***	0.809**	0.775***
	(0.044)	(0.075)	(0.184)	(0.343)	(0.216)
N	2399.000	2399.000	2399.000	2399.000	2399.000
Wald chi2		8507.737	4296.788	3196.084	4692.439
Prob ¿ chi2	.	0.000	0.000	0.000	0.000

The table displays coefficients, bootstrapped standard errors are in parentheses;
*, ** and *** denote significance levels 10%, 5% and 1%
The dependent variable, the predicted technical efficiencies, are based on a stochastic frontier estimation that assumes time-varying u
Column 2: Budget shares are not instrumented
Column 3: Budget shares are instrumented using a one year lag
Column 4: Budget shares are instrumented using a two year lag
Column 5: Budget shares are instrumented using a three year lag
Column 6: Budget shares are instrumented using country averages

Table 9: *GMM Regressions of Estimated Technical Efficiencies on Budget Shares*

	Pooled Frontier	Time-Varying Panel Frontier
L.Efficiency	0.293***	1.004
	(0.099)	(0.687)
Bsha Tuition	-0.001	-0.000
	(0.039)	(0.035)
Bsha Int Public	0.003	-0.000
	(0.005)	(0.003)
Bsha Private	0.016*	-0.000
	(0.008)	(0.012)
Finland	-0.001	-0.001
	(0.300)	(0.228)
Italy	-0.139*	0.000
	(0.080)	(0.149)
Netherlands	-0.083	-0.000
	(0.063)	(0.139)
Norway	0.312	0.009
	(0.590)	(1.815)
Portugal	-0.069	0.000
	(0.089)	(0.243)
Spain	0.031	-0.001
	(0.098)	(0.210)
United Kingdom	-0.046	0.001
	(0.108)	(0.355)
Trend_Finland	-0.001	-0.000
	(0.003)	(0.003)
Trend_Italy	0.005	-0.000
	(0.004)	(0.004)
Trend_Netherlands	0.009**	-0.000
	(0.004)	(0.006)
Trend_Norway	0.012	-0.000
	(0.008)	(0.006)
Trend_Portugal	0.008	-0.000
	(0.011)	(0.008)
Trend_Spain	-0.001	0.000
	(0.003)	(0.003)
Trend_Switzerland	-0.005	0.000
	(0.008)	(0.009)
Trend_United Kingdom	0.004**	0.000
	(0.002)	(0.005)
Constant	0.460***	-0.006
	(0.123)	(0.494)
N	2103.000	2103.000
Wald chi2	139.160	6.426e+08
Prob ¿ chi2	0.000	0.000

The table displays coefficients, robust standard errors are in parentheses;
*, ** and *** denote significance levels 10%, 5% and 1%
The presented estimates correspond to two-step system GMM estimations, assuming that only budget shares are endogenous.
Column 2: Predicted inefficiency, û, based on pooled stochastic frontier
Column 3: û based on panel stochastic frontier assuming time-varying inefficiency

Table 10: *Regressions of Estimated Technical Efficiencies on Budget Shares including alternative sets of controls*

	Pooled, FullFE	Pooled, Plain	VarPanel, FullFE	VarPanel, Plain
Trend_Finland	-0.006***		-0.004***	
	(0.000)		(0.000)	
Trend_Italy	-0.004***		-0.004***	
	(0.001)		(0.000)	
Trend_Netherlands	0.004		-0.003***	
	(0.002)		(0.000)	
Trend_Norway	0.028***		-0.003***	
	(0.000)		(0.000)	
Trend_Portugal	0.002		-0.003***	
	(0.005)		(0.000)	
Trend_Spain	-0.002***		-0.004***	
	(0.000)		(0.000)	
Trend_Switzerland	0.009***		-0.003***	
	(0.002)		(0.000)	
Trend_United Kingdom	-0.001***		-0.004***	
	(0.000)		(0.000)	
Bsha Tuition	0.007	-0.001	-0.001**	-0.008
	(0.015)	(0.002)	(0.000)	(0.014)
Bsha Int Public	0.004	0.009**	-0.000	-0.011
	(0.003)	(0.003)	(0.000)	(0.008)
Bsha Private	0.005**	0.007	-0.000	0.017*
	(0.002)	(0.005)	(0.000)	(0.009)
Constant	0.421***	0.631***	0.234***	0.375***
	(0.017)	(0.023)	(0.001)	(0.086)
N	2399.000	2399.000	2399.000	2399.000
Wald chi2				
Prob ¿ chi2	.	0.005	.	0.267

The table displays coefficients, robust standard errors clustered at country level in parentheses;
*, ** and *** denote significance levels 10%, 5% and 1%
Column 2 and 3: û based on pooled stochastic frontier
Column 4 and 5: û based on panel stochastic frontier assuming time-varying inefficiency
Column 2 and 4: Inclusion of full set of fixed effects beside of country-specific trends
Column 3 and 5: No country-specific controls included

Table 11: *Estimates of Simplified Pooled Stochastic Frontier by Country*

	Italy	NL	Portugal	Spain	UK
lq2	-0.243**	-0.054	-0.117	0.064	-0.440***
	(0.114)	(0.342)	(0.235)	(0.163)	(0.049)
lq3	-0.126**	-0.752**	-0.255	0.257*	-0.196***
	(0.057)	(0.378)	(0.212)	(0.150)	(0.046)
q2q2	-0.035**	-0.424***	-0.158	0.007	-0.112***
	(0.017)	(0.154)	(0.387)	(0.034)	(0.012)
q3q3	-0.020**	0.325	-0.075	0.236**	-0.053***
	(0.010)	(0.212)	(0.127)	(0.095)	(0.018)
q2q3	0.006	-0.249	-0.097	-0.034	0.052***
	(0.006)	(0.204)	(0.216)	(0.058)	(0.015)
lx1	0.244	0.313	0.155	0.173	0.398***
	(0.558)	(0.571)	(0.593)	(0.122)	(0.064)
lx2	0.855	1.111*	0.645	0.321***	0.409***
	(0.587)	(0.572)	(0.601)	(0.077)	(0.046)
x1x1	0.219	-0.001	-0.082	0.181**	0.070***
	(0.196)	(0.307)	(0.239)	(0.071)	(0.011)
x2x2	-0.109	0.231	0.182	0.040	0.070***
	(0.187)	(0.307)	(0.285)	(0.045)	(0.015)
x1q2	-0.005	0.172	-0.102	0.006	-0.025
	(0.050)	(0.315)	(0.405)	(0.092)	(0.021)
x1q3	-0.022	0.096	-0.197	-0.279***	-0.003
	(0.061)	(0.299)	(0.284)	(0.054)	(0.012)
x2q2	0.022	-0.166	0.102	-0.177	0.058*
	(0.053)	(0.303)	(0.457)	(0.109)	(0.031)
x2q3	0.041	-0.489	0.137	0.234***	-0.031
	(0.069)	(0.327)	(0.357)	(0.056)	(0.024)
Trend_Finland	.	.	.	.	.
	.	.	.	.	.
Trend_Italy	-0.005	.	.	.	.
	(0.029)	.	.	.	.
Trend_Netherlands	.	0.039***	.	.	.
	.	(0.006)	.	.	.
Trend_Norway	.	.	.	.	.
	.	.	.	.	.
Trend_Portugal	.	.	0.003	.	.
	.	.	(0.035)	.	.
Trend_Spain	.	.	.	-0.010***	.
	.	.	.	(0.003)	.
Trend_Switzerland	.	.	.	.	.
	.	.	.	.	.
Trend_United Kingdom	.	.	.	.	-0.011
	.	.	.	.	(0.007)
Bsha Tuition	0.128*	0.190*	-0.021	0.303***	-0.569***
	(0.075)	(0.112)	(0.067)	(0.091)	(0.059)
Bsha Int Public	-0.001	-0.007	-0.035	-0.059***	0.008
	(0.021)	(0.007)	(0.091)	(0.015)	(0.019)
Bsha Private	-0.088***	-0.008	-0.102	0.040***	0.026
	(0.034)	(0.027)	(0.151)	(0.011)	(0.028)
Constant	0.494	0.787***	0.719**	0.078	1.174***
	(0.304)	(0.294)	(0.338)	(0.128)	(0.093)
lnsig2v					
Constant	-4.446	-4.869	-4.383	-5.022	-2.979***
	(12.480)	(11.208)	(14.444)	(10.720)	(0.149)
Inefficiency					
Bsha Tuition	-0.648***	10.160	6.592	-0.559	-3.546***
	(0.174)	(33.197)	(4.490)	(0.649)	(0.364)
Bsha Int Public	0.022	-0.033	1.238	-0.832***	-0.173
	(0.108)	(2.424)	(1.538)	(0.239)	(0.116)
Bsha Private	-0.314***	0.449	-0.719	1.101***	-0.364***
	(0.119)	(6.954)	(2.419)	(0.168)	(0.119)
Constant	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	463.000	120.000	70.000	513.000	923.000
Wald chi2	123534.552	2926.040	1632.831	4948.351	108991.288
Prob ¿ chi2	0.000	0.000	0.000	0.000	0.000

The table displays coefficients, robust standard errors clustered at country level in parentheses; *, ** and *** denote significance levels 10%, 5% and 1%